

inæquilateral, umbones prominent, oblong in form, being somewhat produced posteriorly; the ligament is external; teeth in right valve apparently three, in the left two, all cardinal; inner surface subpellucid, white; pallial line with a conspicuous sinuosity.

Several examples, but only a very few in mature condition.

## EXPLANATION OF THE PLATES.

## PLATE I.

- Fig. 1. *Nassa* (*Hima*) *ischna*.  
 Fig. 2. *Drillia* *theoretæ*.  
 Fig. 3. *Mangilia* *chilosema*.  
 Fig. 4. — *galigensis*.  
 Fig. 5. — *perlonga*.  
 Fig. 6. — *theskeloides*.  
 Fig. 7. *Clathurella* *O'Maleyi*.  
 Fig. 8. *Lutirus* (*Peristernia*) *pagodæformis*.  
 Fig. 9. *Erato* *olivaria*.  
 Fig. 10. *Scalaria* (*Cirsotrema*) *hidryma*.  
 Fig. 11. — (*Constantia*) *Standeni*.  
 Fig. 12. *Cerithiopsis* (*Scila*) *bandorensis*, Melv.  
 Fig. 13. *Actæopyramis* *Psyche*.  
 Fig. 14. *Odostomia* *eutropia*.  
 Fig. 15. *Pyrgulina* *epentromidea*.  
 Fig. 16. — *glycisma*.

## PLATE II.

- Fig. 1. *Fusus* *Townsendi*.  
 Fig. 2. *Mitra* (*Pusia*) *Elizæ*.  
 Figs. 3, 3 a. *Mitra* (*Costellaria*) *revelata*.  
 Fig. 4. *Natica* *Ponsonbyi*.  
 Fig. 5. *Lacuna* *tenuistriata*.  
 Fig. 6. *Prietrochus* *sepulchralis*.  
 Fig. 7. *Macrinula* *tryphera*.  
 Fig. 8. *Lucina* (*Codakia*) *angela*.  
 Figs. 9, 9 a. *Cryptodon* *victorialis*.  
 Fig. 10. *Scintilla* *calliparcia*.  
 Fig. 11. *Diplodonta* *holosphæra*.  
 Fig. 12. ? *Ædulina* *asiutica*.

## VI.—Observations on the Classification of Birds.

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IN former papers of mine the classification of various groups of birds has been treated, their osteology, as a rule, being the anatomical system employed and referred to for the purpose.

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These investigations, as many are aware, have not been confined entirely to recent avifaunæ, but have also taken into consideration fossil material, the remains of birds that existed as far back as Tertiary time.

So far as the United States ornis is concerned, every family, or, indeed, nearly every genus of the recent age, has thus been dealt with, and some of the MSS. presenting the details of these researches have been published, while the far greater proportion of them temporarily await a similar disposition. It is in this manner that such groups as the Passeres, the Swifts, the Humming-birds, the Goatsuckers, the Trogons, the Kingfishers, and many others have been gone over and issued in the form of memoirs in different publications, while upon the other hand the osteology of entire groups has been written out and illustrated, and will, when printed, fill in gaps that formerly existed. Among these last, extensive work has also been done with large and small groups of birds not occurring in this country, as the Penguins, the Ostriches, and others. These will not be taken especially into consideration in the present connexion, for the reason that considerable unanimity of opinion exists among naturalists with respect to their taxonomy; though probably the Penguins form an exception to this statement. Commencing in the United States avifauna with the Pygopodes, however, and passing the various groups in review, following their linear arrangement in the order in which they are usually printed, we meet not only with single species but with groups of species, as to the true taxonomic position of which in the system ornithologists entertain very diverse opinions. It is to these that it is my intention to refer in the present paper. They have all been closely studied osteologically, and in the case of many of them their general anatomy has been investigated and their biology as a whole given weight. My views upon the classification and systematic position of some of these families or species now in my mind have been briefly abstracted and published either in 'The Ibis' of the British Ornithologists' Union or in the 'Proceedings' of the Zoological Society of London. Others there are that have not been so noticed.

Prior to passing to the aforesaid subject-matter in chief, however, it may be as well first to pay some attention to the morphological characters of birds, with special reference to their use in determining a scheme for the natural classification of the class. By the natural classification of Aves is meant an orderly arrangement of existing birds into major and minor subdivisions according to their true affinities as they actually obtain in nature. That a real relationship exists among

certain and various tribes of birds, since the time they have, through their evolution, become differentiated from their remote reptilian stock, is a fact that it is feared those who attempt their taxonomy do not always keep impressed with sufficient strength upon their minds. Consequently we often hear of this classifier's arrangement, and that classifier's arrangement or scheme, just as though no real affinities existed, whereas it is the duty of each and every one attempting a taxonomic scheme to discover precisely how the avian tree has thrown out its branches and its twigs, and, if possible, determine the points from where they sprung. Equally useless is it to attempt a classification of birds by selecting for the purpose the ornithology of any particular area of the earth's surface. Those that enter upon the task by applying to taxonomic ornithology the birds occurring within arbitrary political boundaries as mapped out by man will fail utterly, and such a piecemeal provisional classification will, with the greatest certainty, be broken up the moment the first far-seeing taxonomer tests it with the morphological facts gathered from the entire class, both existing and extinct, as far as they are known to science. For this reason we must consider all the classifications of birds up to the present time as being merely provisional, inasmuch as we are yet so far from possessing the necessary knowledge to define the true one, based upon the complete biological history of the class. A study of the various classificatory schemes that have been presented within the last twenty-three centuries will convince any one that there has been just as much of an evolution in this field as there has been in the case of birds themselves. It must be remembered in this connexion that even as early as Aristotelian time birds were classified into groups, and Pliny, adhering to much that had been done five centuries before him, selected only the very obvious characters of the feet for the purpose, which threw all the birds known to him into three divisions, of which a Hawk, a Hen, and a Goose were respectively representative. Thus were associated the Ducks and Cormorants, the Rails and Robins—and this is what the feet did. Ornithology was placed upon a scientific basis about the middle of the seventeenth century through the labours of Willughby and Ray. They were the first to use the two main divisions of Land- and Water-birds, and in subdividing both the bills and feet were used as classificatory characters. For the most part Linnæus followed Ray, and in doing so kept many birds in taxonomic juxtaposition where the affinity was quite remote. Mergansers and Albatrosses were kept together, as were Divers and Gulls—and so much for what bills and feet

did in those days. Improvement over early authors was very evident, however, and many palpable errors were rectified. From such beginnings the science has grown up, authors and classifiers being more and more numerous with each succeeding generation. Some used one set of characters and some another; but it is to be distinctly noticed that the previous taxonomic schemes have always influenced their followers in later years. Merrem, who in 1812 was perhaps the first to publish a systematic arrangement of the groups of birds, was doubtless influenced by all that had been accomplished prior to his time, as the work of Nitzsch in pterylography, Cuvier in structure, and Linnæus and Ray in a number of external characters. His scheme was a solid contribution to the classification of birds, based as it was upon a variety of anatomical characters, as those drawn from the sternum, those from the feathers, those from the osseous system, and those from other parts, as the bills and feet. In fact Merrem took a long step in the direction of the truth, or, rather, in the discovery of the true relationships of birds in nature.

De Blainville quickly followed Merrem, and again rearranged the avian scheme of classification, fascinated as he was by the characters presented on the part of the body of the sternum. In some directions further advancement was evidenced, however, and this advancement later on was powerfully increased by the labours of Nitzsch, who brought into play the arterial system, the song-muscles, the nasal glands, and other morphological features.

Thus, from the time of Nitzsch down to the present day the classification of birds has gone through many changes and many phases at the hands of the ornithologists of the succeeding generations as they have passed. The greatest advances have been made since the scientific demonstration of the law of organic evolution and the derivation of birds became known, and these by the men who have studied the subject from that standpoint. Were it possible for us now to know the complete biology of every bird-form that has existed upon the earth since birds as birds came into existence, there would be among ornithologists an agreement of opinion upon their classification, the world over, within a twelvemonth. If half the species that have existed were known, the scheme would almost work itself out. As it is, we probably see to-day in the world's avifauna but a paltry remnant of that enormous and unknown host, and it will be generations yet to come ere there will be a consensus of opinion upon the affinities of this puzzling and very homogeneous group of vertebrates. When compared with other major groups of animals, either verte-

brate or invertebrate, the structural differences to be found among the forms making up the natural minor groups of existing birds are far less apparent than in any one of them. Taken in their entireties, the difference between an Apteryx and a Humming-bird morphologically is not to be compared with what exists, when thus contrasted, between such forms, for example, as a man and an *Ornithorhynchus* among mammals, or between a Lancelet and a Bass among fishes. Birds are an extremely compact group, and the disposition is altogether too prevalent, in attempts to classify them, to accord too high a rank to not a few of the divisions above the family. Were birds fishes the entire congregation of them would hardly make more than a respectable order. They are a lucky lot of closely affined volant feathered reptiles that have specifically multiplied at a wonderful rate since they sprang into existence, and useful and charming as the majority of them are in nature, their taxonomy nevertheless has puzzled the wits of many a man since Aristotle lived, and will doubtless continue to do so in the years to come. To arrive at their true affinities and a natural grouping of the class it will be necessary to utilize every fact that we possess in regard to their biology; by this it is meant every palæontological fact, every fact referring to geographical distribution for all time, every morphological fact, besides all that is known of their biology, habits, and development. In so far as their anatomy is concerned, some of the systems have undoubtedly proved to be of more value than others in the matter of classification. For example, in this particular the study of the skeleton teaches us more than a comparison of the dermal appendages, but the osseous system is by no means all-sufficient to meet the ends of taxonomy, as some still seem to believe. With regard to this, it is easy to agree with what Professor Alfred Newton has said, when commenting upon the value of the work left us by Nitzsch, for "there can be no part of a bird's organization that by proper study would not help to supply some means of solving the great question of its affinities. This seems to the present writer to be one of the most certain general truths in zoology, and is probably admitted in theory to be so by most zoologists, but their practice is opposed to it; for, whatever group of animals be studied, it is found that one set or another of characters is the chief or favourite of the authors consulted—each generally taking a separate set, and that to the exclusion of all others, instead of effecting a combination of all the sets and taking the aggregate." Thus it is that, notwithstanding the relative value of the characters furnished on the part of any particular

morphological system, as indicating interexisting affinities, that value is certain to be affected when the facts brought out by a study of another system, as the muscular system, for example, are applied to it. As evident as this is, however, we have not far to seek in order to discover avian classifiers who would be content to base their taxonomic scheme of the class upon some single character of some special system, as, for instance, De Blainville did in using only the body of the sternum for the purpose. Such a practice lands one not very far from the plane arrived at by Pliny in the first century.

Dr. Alfred Russel Wallace, in criticizing a memoir of Mr. Blanchard's in 'The Ibis' for the year 1864, says very truly that we should make the greatest errors in classification by following the sternum alone, as, "for example, the sterna of the Finches and the Flycatchers are scarcely distinguishable, notwithstanding the great dissimilarity in almost every part of the structure of these birds—their bills, their feet, their plumage, their habits, food, and digestive organs. On the other hand, the sterna of the several genera of the Caprimulgidæ differ from each other more than those of the most distinct families of the restricted Passeres. The Bee-eaters, the Barbets, and the Woodpeckers, again, are three very distinct families, which, in a classification founded upon all parts of a bird's organization, cannot be brought in close contact; and yet their sterna, according to Mr. Blanchard, much resemble each other. It is evident, therefore, that the whole structure of a bird and its corresponding habits may be profoundly modified, and yet the sternum [may retain a very close resemblance to a common form; and, on the other hand, the sternum] \* may undergo important changes, while the general organization and habits are but little altered." So much for the value of single anatomical systems in avian taxonomy, and so much for the value of single characters in any system. Now as to the value of osteology as a whole in the classification of birds, no ornithologist or classifier of this group of vertebrates will for a moment doubt. Employed in its entirety the osseous system of Aves stands far in advance of any other in settling the question of affinities and affording characters in classification. It has been almost entirely through our studies of the fossil skeletons of birds that we have been enabled to fix their origin in time or to link them with their extinct reptilian ancestors.

\* [The passage between brackets is as it stands in 'Ibis,' and has probably been omitted by accident in the Proc. Ac. Nat. Sc. Phil.—Eds.]

The researches of the Parkers in the development of the embryological skeleton of birds; of Huxley in the skull; and the labours of Macgillivray, Nitzsch, Merrem, De Blainville, L'Herminier, Cuvier, St.-Hilaire, Gervais, Blanchard, Eytton, Owen, Garrod, Forbes, Fürbringer, Gadow, Lucas, Beddard, and many others upon the general skeleton; with the study of palæontological osteology by Milne-Edwards, Cope, Marsh, and their colleagues in the same field, would, when taken in the aggregate, go far toward establishing a natural classification, or, rather, toward indicating the true affinities of birds.

Still, in face of all this, we must believe that osteology is by no means an all-sufficing guide, nor has it been in the mind of the present writer in his attempts to discover the true kinships existing among birds, their systematic positions, and the places the various natural groups should occupy in any scheme of classification.

On the contrary, the aim has been to examine with care into the results of the anatomical and general biological investigations of birds by whomsoever they may have been undertaken and published, so long as those researches seemed to have any bearing upon the solution of the true affinities of the class. With this in view a very wide field of literature has been considered and the works of a great many authors examined. All through this osteology has held the main place, but constantly subject to subordination when factors drawn from other anatomical systems or from the general life-histories of the bird-groups possessed beyond all doubt greater weight and significance.

Bearing this in mind, and from osteological premises, let us now proceed to examine into the probable affinities of certain birds or groups of birds and how we should classify them. An inquiry of this kind would hardly seem to require any apology, inasmuch as no two systematists of all those who have published a scheme of classification for Aves since 1867, when Professor Huxley gave us his, agree upon the position in the system and the affinities of not a few of the natural avian assemblages. Take, for example, the Grebes and Loons. Huxley associated them with the Laridæ, Procellariidæ, and Alcidæ in his group Cecomorphæ; Garrod placed them among the Ducks and Penguin in the Anseres; Forbes included the Heliornitidæ with them, and created a new group, Eretopodes; Dr. Selater retained them as a family Colymbidæ with the Alcidæ in the order Pygopodes; Reichenow did the same, but added the Penguins to the group and called the order Urinatores; they are a family of a superfamily, and associated with four other superfamilies,

of the Cecomorphæ in Dr. Stejneger's scheme; Dr. Fürbringer giving still other new names for orders, suborders, and genera, places them between the Flamingoes and the extinct Hesperornithidæ; we find them among the Galliformes in Seebohm's arrangement; and, finally, considered as two separate orders by Dr. Sharpe. Still other eminent taxonomers, as Cope, Professors Gadow and Newton, take different views of the subject. In 1890 Professor D'Arcy W. Thompson and the present writer pointed out quite independently of each other the fact that the Loons and Grebes were descendants of the Hesperornithidæ, an opinion previously expressed by Cope and Fürbringer. At great variance with this, Professor Newton, Lydekker, and Marsh contended that these extinct Cretaceous divers were some kind of a natatorial Ostrich. These so-called ostrich or "struthious characters" have been a stumbling-block in times past to more than one avian systematist, but I think their real significance is gradually coming to be better appreciated as time goes on. The great probability is that there was a time in the former history of the class, possibly at about the age when *Hesperornis* flourished, that all birds exhibited such characters in their skeletons. They are retained now only in a few and widely separated groups or families, as the Kiwis, the Tinamus, Ostriches, and some others.

Now, apart from a general and superficial resemblance, a typical Loon and a typical Grebe are not, to judge from their osteology, as near akin as many seem to think. Differences of a very marked character distinguish their skulls, their vertebral columns, their sterna, their pelves, and their limb-bones. Still there is a greater similarity between the skeleton of a Loon and a Grebe than there is between a Loon and any representative of the Alcæ. About this fact I have satisfied myself after having compared, character for character, as they occur in the skeletons of several species of Loons with the corresponding ones in a number of Grebes, and both with all the Auks found in our United States avifauna save *Cerorhinca*. D'Arcy Thompson has shown, beyond all question in my opinion, in his paper "On the Systematic Position of *Hesperornis*," the affinity of our modern or existing Colymbi with that ancient diver. It would seem then that the time cannot be far distant when naturalists can at least agree upon the relations that these birds bear to each other and to kindred groups. To express this relationship, Loons and Grebes should be associated in one and the same suborder, and a superfamily created for either assemblage. In a linear classification I believe their nearest relatives are the Penguins



upon the one hand and the Auks upon the other, with the Heliornithidæ in the next place as a related branch, and one more nearly so than the Laridæ or the Procellariidæ. In part, this is believed by Dr. Stejneger to be the relationship, who, however, widely dissociates the Hesperornithidæ. While this last relationship is fully appreciated by Professor Fürbringer, that eminent authority nevertheless apparently sees no special affinity between an Auk and a Loon or Grebe, and so very widely separates the Colymbo-Podicipites and the Laro-Limicolæ assemblages.

Passing next to the anserine fowls, one would think that by this time there would be more or less unanimity of opinion among systematic ornithologists as to the affinities and position of such a homogeneous group. As a family the existing Anatidæ can but contain the Mergansers, Ducks, Geese, and Swans, while the outliers, either existing or extinct, are not as a rule very puzzling forms. The anserine affinities of *Palamedea* are now pretty generally recognized; and there can be no question as to the relationships of the extinct *Cnemiornis* or *Cereopsis*. Moreover the relation borne by the Flamingoes to the Anseres has been known for a good many years past, and yet, notwithstanding all this, we find almost as much diversity of opinion among the classifiers of birds as to where this very natural group belongs, as has already been pointed out in regard to the Pygopodes. After a careful examination and comparison of the skeleton of *Palamedea*, all of our United States Anseres except one or two species, the Flamingoes, including the extinct ones and *Palvolodus*, and a great many species and genera of Herons, Ibises, Storks, *Scopus*, and their allies near and remote, and, finally, an equal number of the Steganopodes, I was led to believe a year or two ago that the duck tribe in its widest sense, with the allied suborders containing the Palamedeidæ, the Phœnicopteridæ, and their fossil relatives, constituted a group, the nearest related branches to which were the Steganopodes upon the one hand and the Herodiones upon the other. An opinion practically quite similar to this is entertained by Dr. Sharpe and Dr. Stejneger, while on the other hand Dr. Gadow places the Anseriformes between the Falconiformes upon the one hand and the Crypturiformes upon the other, which of course is an utterly different view of their relationships. To discuss these latter here is obviously out of the question, as it would carry the present paper far beyond its limits. Before turning from the Anseres, however, I desire to say that I have found some interesting osteological points in the skeleton of *Dendrocygna autumnalis*, one of the tree-

ducks. Although presenting several anatomical peculiarities, this genus is one containing several species of ducks, and ducks not so very far removed from either the Teals, or the Mallard, or perhaps *Spatula*. There is very little Goose, and still less Swan, in the morphology of *Dendrocygna*, and for what reason the genus has been placed between *Philacte* and *Olor* in the 'Check-list' it is difficult for me to understand. In the first edition of his 'Manual' Mr. Ridgway places *Dendrocygna* the last genus in the duck-series where the synopses of characters of the Anseres are set forth, while in the part devoted to the diagnoses of species and genera these

Fig. 1.



Fig 2.



Fig. 1.—Right lateral view of the skull of *Dendrocygna autumnalis*, showing complete bony ring surrounding orbit. Pterygoids lost. From a photograph by the author.  $\frac{2}{3}$  nat. size.

Fig. 2.—Right lateral view of part of trunk-skeleton of same specimen.  $\frac{2}{3}$  nat. size.

Tree-Ducks are placed between the Swans and the Geese, as in the 'Check-list.' They have, as I have just said, some peculiar characters about them, and of these one of the most interesting is the fact that they have complete bony rings surrounding the orbits, as is the case in several genera of parrots and some other birds. So far as I am aware it is the only genus of ducks that presents this character—indeed, the only anserine bird that has it.

Coming to the Cranes and Rails we meet with an interesting

form in *Aramus giganteus*. During the past few years I have compared the skeletons of several hundred species of birds and written out the osteology of nearly every genus in this country, and among all these have been included the entire Crane and Rail group with all the North-American birds in any way related to it. In this manner have *Grus*, *Aramus*, *Rallus*, *Porzana*, *Crex*, *Ionornis*, *Gallinula*, *Fulica*, and others been dealt with, and their skeletal characters arrayed in tabular form in great detail. Without entering upon the general taxonomy of this group, it is an interesting fact that, in so far as the skeletal characters are concerned, *Aramus* presents two for every one in favour of its affinity with *Grus* as compared with *Rallus*; yet in nearly all avian classifications we find this bird arrayed with the typical Rails. Four years ago I published in England an abstract in which was incorporated some of the facts here stated, with part of a scheme for the classification of this group. Since then I have examined a number of forms at that time not available, and although they have not materially altered my original views, some changes will necessarily have to be made in order to include those facts which have since come before me.

Of recent years nothing has come to my notice that seems likely to again check the now growing opinion that the Woodpeckers, as another assemblage of birds, see their nearest relatives in the Passeres, and they do not possess those vestiges of lacertilian morphology in the bases of their crania that were formerly supposed to exist there. The double vomers that a few years ago were attributed to them are now generally conceded to be nothing more than mesial edges of the imperfectly ossified palatines, as was pointed out by Garrod in 1872. In that year Garrod printed a brief paper in 'The Ibis,' in which he claimed that *Gecinus viridis* and its allies possessed a median vomer, though it was differently formed from the bone as it occurs among some of the Passerine birds. Nevertheless Dr. Sharpe, as late as 1891, in his extremely useful brochure 'Recent Attempts to Classify Birds,' still claims saurognathism for the *Pici*, although in the same paragraph he admits that in this entire suborder the "vomer is slender, pointed, and split" (p. 84). It is not difficult to believe that all of the alleged saurognathous characters in the skull and associated bony arches of the woodpeckers are due to changes wrought in time through the special habits of this particular group of birds, rather than that they stand in evidence as structural remnants inherited from their ancient reptilian ancestors.